NASA TECH BRIEF

Temperature-Independent Resistor for Microelectronic Circuits

The problem:

To develop a resistive device in electronic equipment which is temperature-independent from 77° to 295°K.

The solution:

Heat treat temperature-independent, insulating crystals in a gaseous hydrogen atmosphere in order to induce the desired level of resistivity. Increasing the concentration of hydrogen within the crystal yields semiconductor, "hybrid" and metallic conduction characteristics. The combination of these modes of conduction and a depletion layer at the surface gives the insulating crystal resistive properties which are virtually temperature-independent.

How it's done:

Pure strontium titanate ($SrTiO_3$) crystals with initial resistivities in excess of 10^{11} ohm-cm were heated to 900° C in a gaseous hydrogen atmosphere. It was found that the dissolved hydrogen could reduce the resistivity of the $SrTiO_3$ crystals from 10^4 ohm-cm to 10 ohm-cm. Four-point probe measurements for the heavily doped crystals showed a metallic behavior, i.e., a positive temperature coefficient; this suggests that the resistivity is not a property of the bulk but of the crystal surface.

The dramatic change in the electrical properties of $SrTiO_3$ crystals by doping them with hydrogen can be explained as follows: lightly doped samples behave as semiconductors with a bandgap (about 0.090 eV) that tends to decrease with increasing hydrogen concentration. Metallic properties appear at room temperature with hydrogen concentrations of about 5×10^{17} atoms/cm^3. However, the sample is still semiconducting at lower temperatures. If the hydrogen concentration exceeds 2×10^{18} atoms/cm^3, the crystal becomes purely metallic.

It can be expected that other crystals, such as $BaTiO_3$, may exhibit similar phenomena.

Notes:

1. This device could be applied as a temperature-independent resistor in electronic equipment which is to be subjected to a wide range of temperatures. The use of temperature-independent resistors would enable circuit designers to eliminate temperature-compensation circuits.
2. No further documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics
   and Space Administration
   Washington, D.C. 20546
   Reference: B70-10276

Patent status:

No patent action is contemplated by NASA.

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